Patent claims

1. A/D converter comprising a self-oscillating modulator, said converter comprising

at least one self-oscillating loop comprising
at least one forward path,
at least one feedback path,

wherein said at least one forward path comprises amplitude quantizing means combined with time quantizing means and outputting at least one time and amplitude quantized signal.

2. A/D converter comprising a self-oscillating modulator according to claim 1, wherein said time quantizing means is arranged within said self-oscillating loop.

3. A/D converter comprising a self-oscillating modulator according to claim 1 or 2, wherein said time quantizing means comprises a high-speed sampling means.

4. A/D converter comprising a self-oscillating modulator according to any of the claims 1-3,
wherein said time quantizing means comprises a high-speed one-bit sampler.

5. A/D converter comprising a self-oscillating modulator according to any of the claims 1-4,
wherein said time quantizing means comprises latch-based circuitry comprising at least one latch, preferably at least two cascaded latches.

6. A/D converter comprising a self-oscillating modulator according to any of the claims 1-5,

wherein said amplitude quantizing means and said time quantizing means comprises a multi-bit A/D converter and where said feedback path comprises at least one D/A converter adapted for converting said time quantized signal into an analogue signal.

7. A/D converter comprising a self-oscillating modulator according to any of the claims 1-6,
wherein down sampling means are connected to said time quantizing means.

8. A/D converter comprising a self-oscillating modulator according to any of the claims 1-7,
wherein said A/D converter comprises two or more self-oscillating loops (SOL).

9. A/D converter comprising a self-oscillating modulator according to any of the claims 1-8,
wherein said amplitude time quantizing means comprises an analogue two-level self-oscillating pulse width modulator.

10. A/D converter comprising a self-oscillating modulator according to any of the claims 1-9,
wherein said amplitude time quantizing means comprises a multi-level self-oscillating pulse width modulator.

11. A/D converter comprising a self-oscillating modulator according to any of the claims 1-10,
wherein said A/D converter is single-ended.

12. A/D converter comprising a self-oscillating modulator according to any of the claims 1-11,
wherein said A/D converter is differential.

13. A/D converter comprising a self-oscillating modulator according to any of the claims 1-12,
wherein said A/D converter comprises filtering means, said filtering means adapted for band pass filtering the time quantized signal.

14. A/D converter comprising a self-oscillating modulator according to any of the claims 1-13, wherein the error originating from at least one time quantizer included in the at least one self-oscillating loop of the converter is suppressed by an error transfer function which, at low frequencies approximates the inverse of the open-loop transfer function of said at least one self-oscillating loop.

15. A/D converter comprising a self-oscillating modulator according to any of the claims 1-14, wherein the error originating from at least one time quantizer included in the at least one self-oscillating loop of the converter is suppressed by an error transfer function which, at high frequencies approximates 0 dB.

16. A/D converter comprising a self-oscillating modulator according to any of the claims 1-15,
wherein said amplitude quantizing means comprises a limiter.

17. A/D converter comprising a self-oscillating modulator according to any of the claims 1-16, wherein said amplitude quantizing means comprises a frequency compensated limiter.

18. A/D converter comprising a self-oscillating modulator according to any of the claims 1-17,
wherein a variable self-oscillating loop delay is applied.

19. A/D converter according to any of the claims 1-18,

wherein A/D converter switches with a switch frequency which is at least partly defined by the at least one self oscillating loop.

20. A/D converter according to any of the claims 1-19, wherein the switch frequency is at least 200 kHz, preferably at least 300 kHz.

21. A/D converter according to any of the claims 1-20, wherein said A/D converter comprises switch frequency control means.

22. A/D converter according to any of the claims 1-21, wherein said switch frequency control means comprises a variable delay in said at least one self oscillating loop.

23. A/D converter according to any of the claims 1-22, wherein said switch frequency control means comprises an additional periodic signal generator connected to the self oscillating loop.

24. A/D converter according to any of the claims 1-23, wherein said switch frequency control means comprises an oscillator or a derivative of a clock frequency.

25. A/D converter according to any of the claims 1-24, wherein said at least one forward path comprises a non-linearity.

26. A/D converter according to any of the claims 1-25, wherein said non-linearity comprises a limiter.

27. A/D converter according to any of the claims 1-26, wherein said non-linearity comprises a frequency compensated limiter.

28. A/D converter according to any of the claims 1-27, wherein said non-linearity comprises a comparator.

29. A/D converter according to any of the claims 1-28, wherein said non-linearity comprises a operational amplifier.

30. A/D converter according to any of the claims 1-29, the phase contribution of hysteresis in the non-linearity of the self-oscillating loop is less than 90°, preferably less than 40° at the switch frequency.

31. A/D converter according to any of the claims 1-30, the phase contribution of hysteresis in the non-linearity of the self-oscillating loop at the switch frequency is less than 20°, preferably less than 10°.

32. A/D converter according to any of the claims 1-31, wherein said at least one forward path and said at least one feedback path forms at least one self-oscillating loop.

33. A/D converter according to any of the claims 1-32, wherein said self-oscillating loop forms a pulse width modulator and wherein the modulation of an analog input signal fed to the at least one forward path is pulse width modulated at least partly by oscillations established in said at least one self-oscillating loop.

34. A/D converter according to any of the claims 1-33, wherein said self-oscillating converter comprises at least one analog input connected to said forward path and wherein the output of said forward path is connected to a digital output.

35. A/D converter according to any of the claims 1-34,

wherein a transfer function H(s) is inserted in the forward path, thereby at least partly controlling the switch-frequency.

36. A/D converter according to any of the claims 1-35, wherein the order of said transfer function is at least one.

37. A/D converter according to any of the claims 1-36, wherein the order of said transfer function is at least two.

38. A/D converter according to any of the claims 1-37, wherein the effective order of said transfer function is at least one, preferably substantially two.

39. A/D converter according to any of the claims 1-38, wherein said A/D converter comprises an audio A/D-converter.

40. A/D converter according to any of the claims 1-39, wherein the clock frequency of the time quantizing means is at least 10 (ten) times greater than the switch frequency of said at least one self-oscillating loop, preferably at least 100 (hundred) times greater.

41. A/D converter according to any of the claims 1-40, wherein said quantization in the time domain is performed within said at least one self-oscillating loop.

42. A/D converter according to any of the claims 1-41, wherein said A/D further comprises at least one decimator communicating with the digital output.

43. A/D converter according to any of the claims 1-42,

wherein said decimator comprises an anti aliasing filter having an impulse response which longer that period of the pulse width modulated signal, preferably at least longer than three times the period of the pulse width modulated signal.

44. Method of pulse width modulating an analog input signal into a pulse width modulated digital signal, whereby said analog input signal is modulated into a pulse width modulated representation by means of at least one self-oscillating loop

said self-oscillating loop comprising

at least one forward path,

at least one feedback path,

wherein said at least one forward path comprises amplitude quantizing means combined with time quantizing means and outputting at least one time and amplitude quantized signal,

45. Method of pulse width modulating an analog input signal according to claim 44, wherein said analog signal comprises an audio or audio derived signal.

46. Method of pulse width modulating an analog input signal according to claim 44 or 45,

whereby the method comprises the steps of representing a pulse width modulated representation as an analogue signal and quantizing the pulse width modulation in the time-domain and whereby said pulse width modulated representation is obtained by means of at least one self-oscillating modulator comprising at least one self-oscillating loop.

47. Method of pulse width modulating an analog input signal according to any of the claims 44-46,

wherein A/D converter switches with a switch frequency which is at least partly defined by the at least one self oscillating loop.

48. Method of pulse width modulating an analog input signal according to any of the claims 44-47,wherein said switch frequency is at least approximately 100 kHz, preferably at least 200 kHz and most preferably at least 300 kHz.

49. Method of pulse width modulating an analog input signal according to any of the claims 44-48, wherein the clock frequency of the time quantizing means is at least 10 (ten) times greater than the switch frequency of said at least one self-oscillating loop, preferably at least 100 (hundred) times greater.

50. Method of pulse width modulating an analog input signal according to any of the claims 44-49, wherein said method is performed in an audio A/D converter.

51.Method according to any of the claims 44-50, whereby said method is applied in an A/D converter according to any of the claims 1-43.

52. A/D converter according to any of the claims 1-43, wherein the stopband attenuation of the underlying antialiasing filter of the decimator is be greater than 60dB, preferably greater than 100dB.

53. A/D converter according to any of the claims 1-43 and 52, wherein the stopband of the antialiasing filter is:

Stopband = $k \cdot fs_{OUT} \pm BW$, where $k = 1,2,3,\ldots$ until the Nyquist frequency is reached,

fs_{OUT} is the output rate of the decimator and BW is the utility bandwidth, typically preferably at least 20 kHz